

DELAWARE, LACKAWANNA & WESTERN RAILROAD,

DELAWARE RIVER VIADUCT

Pennsylvania Historic Railroad Bridges Recording Project
Spanning Delaware River, north of Portland-Columbia Bridge
Portland VICINITY
Northampton County
Pennsylvania

HAER No. PA-541

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PHOTOGRAPHS

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HISTORIC AMERICAN ENGINEERING RECORD

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Location: Spanning Delaware River, north of Portland-Columbia Bridge, between Portland vicinity, Northampton County, Pennsylvania, and Columbia vicinity, Warren County, New Jersey.

USGS Quadrangle: Portland, Pennsylvania-New Jersey (7.5-minute series).

UTM Coordinates: 18/491045/4531630

Dates of Construction: August 1908 to December 1911.

Basis for Dating: Secondary sources.

Designer: Delaware, Lackawanna & Western Railroad: Benjamin H. Davis, Assistant Chief Engineer, and A. Burton Cohen, Engineer of Concrete Design.

Fabricator: McClintic, Marshall & Co. (Pittsburgh), steel arch centering.

Builder: Smith & McCormick (Easton, Pa.).

Present Owner: Norfolk Southern Railroad.

Present Use: Railroad bridge (abandoned).

Structure Type: Open- and closed-spandrel concrete arches.

Significance: Of the four extremely large concrete arch viaducts constructed by the Delaware, Lackawanna & Western Railroad on straightening projects during the early twentieth century, the Delaware River Viaduct is the only one with a curving, skew alignment. These structures illustrate the railroad's pioneering efforts in reinforced concrete design, the luxury of detail permitted by its ample budget, and its drive to become "one of the most technologically perfect railroads in the nation."

Historian: Justin M. Spivey, April 2000.

Project Information: The Historic American Engineering Record (HAER) conducted the Pennsylvania Historic Railroad Bridges Recording Project during 1999 and 2000, under the direction of Eric N. DeLony, Chief. The project was supported by the Consolidated Rail Corporation (Conrail) and a grant from the Pennsylvania Historical and Museum Commission (PHMC). Justin M. Spivey, HAER engineer, researched and wrote the final reports. Preston M. Thayer, historian, Fredericksburg, Virginia, conducted preliminary research under contract. Jet Lowe, HAER photographer, and Joseph E. B. Elliott, contract photographer, Sellersville, Pennsylvania, produced large-format photographs.

Description and History

During the administration of President William H. Truesdale, the Delaware, Lackawanna & Western Railroad (DL&W) undertook what historian Thomas T. Taber III called an "almost complete reconstruction" of its route between Hoboken, New Jersey, and Binghamton, New York. The success of this expensive project depended on both managerial and engineering expertise. Truesdale came from the Chicago, Rock Island & Pacific Railroad in 1899, and hired Lincoln Bush away from the Chicago & Northwestern in 1903 to serve as the DL&W's Chief Engineer.¹ Together, they planned to use the railroad's profits from mining and shipping coal to finance improvements, the first of which was to be a new, more direct route across western New Jersey. Bush's assistant, George J. Ray, succeeded him as Chief Engineer in 1907. Ray supervised construction of the nearly straight-line route that Bush had laid out between Lake Hopatcong, New Jersey, and Slateford, Pennsylvania, on the west bank of the Delaware River.

The Hopatcong-Slateford (or New Jersey) Cut-Off saved eleven miles, was just two miles longer than the straight-line distance, and rose a maximum of 11'-0" in elevation, as compared to 248'-0" on the old route.² The sharpest curve, just over 3.5 degrees, occurred at the western end of the new route, where it diverged from the old route between Portland and Slateford. Constrained by a steep hill on the Delaware River's west bank, DL&W engineers chose to continue the curve onto a new viaduct across the river. Not only was the entire bridge built on a skew alignment, but four of its nine spans were curved. Reinforced concrete, a material that will take the shape of almost any form into which it is poured, was well-suited to the Delaware River Viaduct's complex geometry.

Bush had specified reinforced concrete for concrete bridges throughout the New Jersey Cut-Off, a policy continued throughout Ray's tenure as Chief Engineer. Under their leadership, the DL&W's use of reinforced concrete garnered many superlatives. Because the railroad carried freight for the cement manufacturing industry, established in the U.S. in the Delaware River valley, it took an early interest in the material. The DL&W's first concrete bridge, a 40'-0" span at Bridgeville, New Jersey, was completed in 1903. "Out of publicity gained from the use of concrete — for the railroad's pioneering work was closely followed by the engineering

profession — came the nickname, the 'reinforced concrete railroad,'" wrote Taber.³ As the railroad proceeded to straighten and flatten its route through northeastern Pennsylvania, broad and deep river valleys provided ample opportunity for constructing spectacular concrete structures. Four received particular attention in the engineering press: the Paulin's Kill and Delaware River viaducts on the New Jersey Cut-Off, and the Martin's Creek and Tunkhannock Creek viaducts on another cut-off between Clarks Summit and Hallstead. The DL&W broke a record for length with the Delaware River Viaduct in 1911, and shattered it just two years later with the Tunkhannock Creek Viaduct, nearly a thousand feet longer.⁴ According to bridge historian David Plowden, the latter structure "remains the biggest and most impressive concrete bridge in America."⁵

The appearance of reinforced concrete was just as important as its other benefits. The contrast of light-colored concrete structures against the surrounding landscape not only enhanced their visual impact, but also echoed the Phoebe Snow character appearing in DL&W advertisements — often wearing a white dress while confidently traveling by train through a region of anthracite coal mines. That economical, low-maintenance structures could be constructed without transporting large components to rural sites helped make the DL&W what historian Richard Saunders called "one of the most technologically perfect railroads in the nation."⁶ That these structures also bore architectural ornament and were nearly pure white in color only enhanced the image of perfection. Concrete could be embellished by simply building detail into the forms. The Delaware River Viaduct's piers, which project to accommodate safety niches, are further enhanced by vertical panels.⁷ A projecting molding along the extrados of each arch separates it from the spandrel piers and emphasizes the structural form.

Benjamin H. Davis, who served as Assistant Chief Engineer under Ray, and A. Burton Cohen, the DL&W's Engineer of Concrete Design, completed detailed design of the Delaware River Viaduct. The nine-span viaduct is 1,452'-0" long between abutments. At its east end, the viaduct begins with a 120'-0" open-spandrel arch, followed by four 150'-0" open-spandrel arches on a straight alignment, all skewed 25 degrees to the river. The curve begins on a fifth 150'-0" span, and continues over another 120'-0" open-spandrel arch, followed by two 33'-0" closed-spandrel arches on the river's west bank, spanning the old DL&W route and State Route 611. Because of the curve, the skew continuously increases to 50 degrees in the westernmost span. In elevation, the longest spans are elliptical arches; the 120'-0" spans, segmental; and the shortest spans, semi-circular. The viaduct is 34'-0" wide throughout, with a clear width of 28'-0" between parapet walls, which carry iron pipe railings with concrete posts. At the piers, safety niches project an additional 4'-0" on either side.⁸

Because it is an early large reinforced concrete structure, the Delaware River Viaduct is based on a conservative design. DL&W engineers viewed the design as somewhat experimental, in fact, and applied what they learned to later structures. While Cohen's later structures had two or even four separate arch ribs, the Delaware River Viaduct's arches extend the entire width of the bridge. The arches are also considerably heavier than later designs, because they were "so proportioned that no tension resulted at any section," in Cohen's words, "and the maximum compressive stress was 525 pounds per square inch."⁹ As a result, the Delaware River Viaduct's

DELAWARE, LACKAWANNA & WESTERN RAILROAD, DELAWARE RIVER VIADUCT
HAER No. PA-541
(Page 4)

150'-0" arches are 6'-0" thick at the crown; its 120'-0" arches, 5'-4" thick. These dimensions would decrease in comparable spans as higher-strength concrete became available, and engineers developed techniques such as precompression to eliminate cracking. Another notable feature of the Delaware River Viaduct is its lack of expansion joints. According to Cohen, the DL&W engineers designed construction procedures that they thought would eliminate the need for such joints. But, after transverse cracks appeared in the Delaware River Viaduct's spandrel arches, they decided to build expansion joints into structures on the Clarks Summit-Hallstead line.¹⁰

Construction of the bridge began in August 1908, although this was preceded by several months of preparations at the site. The contractor, Smith & McCormick of Easton, set up concrete mixing plants on either bank and a cableway spanning the river with an intermediate tower at mid-stream. The concrete piers, constructed first, featured temporary corbels to support the arch centering, which were knocked off after the centering was removed. McClintic, Marshall & Company of Pittsburgh designed, fabricated, and erected steel centering, ten lines of three-hinged trussed arches, re-used for each of the 150'-0" spans. Smith & McCormick used timber centering for the other spans. Because construction of the arches took two years, 1909 and 1910, the fifth pier from the west end had a larger footing and more reinforcement. This enabled it to resist the thrust of spans completed to the east when work stopped for the winter.¹¹ The viaduct opened to traffic shortly after its completion in December 1911. It remained unaltered through several changes in ownership, including the DL&W's merger with the Erie Railroad in 1960, acquisition by a Norfolk & Western Railroad subsidiary in 1968, and transfer to Conrail in 1976.¹² Conrail has subsequently abandoned the line and removed tracks from the bridge.

Notes

1. Thomas T. Taber III, *The Delaware, Lackawanna & Western Railroad, The Route of Phoebe Snow, in the Twentieth Century, 1899-1960* (Muncy, Pa.: Thomas T. Taber III, 1980), 17-20.
2. A. Burton Cohen, "The Delaware River Viaduct," *Purdue Engineering Review* No. 6 (1909-10): 10.
3. Taber, *The Delaware, Lackawanna & Western Railroad*, 36.
4. "The Delaware River Concrete Bridge, Slateford-Hopatcong Cut-off; Delaware, Lackawanna & Western R. R.," *Engineering News* 62, No. 27 (30 Dec. 1909): 713. The Connecticut Avenue Bridge over Rock Creek in Washington, D.C., held the previous record of 1,100'-0".
5. David Plowden, *Bridges: The Spans of North America* (New York: W. W. Norton & Co., 1974), 317. See also U.S. Department of the Interior, HAER No. PA-87, "Erie-Lackawanna Railroad, Tunkhannock Viaduct," 1985, Prints and Photographs Division, Library of Congress, Washington, D.C.
6. Richard Saunders, "Delaware, Lackawanna & Western Railroad," in Keith L. Bryant, ed., *Encyclopedia of American Business History and Biography: Railroads in the Age of Regulation, 1900-1980* (New York: Facts on File, 1988), 112.

DELAWARE, LACKAWANNA & WESTERN RAILROAD, DELAWARE RIVER VIADUCT
HAER No. PA-541
(Page 5)

7. Although perhaps attributable to artistic license, it is interesting to note that a band-colored photo postcard shows these accents in a brownish tint and darker than the surrounding concrete. See Photograph Collections, Box 97, Railroad Museum of Pennsylvania, Pennsylvania Historical and Museum Commission, Strasburg, Pa.
8. Dimensions taken from *Engineering News*, "The Delaware River Concrete Bridge," 713.
9. Cohen, "The Delaware River Viaduct," 12.
10. Cohen, "Expansion and Construction Joints in Reinforced Concrete Viaducts," *Purdue Engineering Review* No. 12 (May 1916): 56-62.
11. Cohen, "The Delaware River Viaduct," 14-17.
12. Saunders, "Delaware, Lackawanna & Western," 113.

Acknowledgment

The author is grateful to Jane S. Moyer, Librarian for the Northampton County Historical Society, for responding to a preliminary survey form.

Additional Sources

1. Milepost 83.80, region/division/branch 106242, aperture card files, Consolidated Rail Corp., Philadelphia, Pa. [transferred to Norfolk Southern Railway Co., Atlanta, Ga.].
2. Robert J. Casey and W. A. S. Douglas, *The Lackawanna Story: The First Hundred Years of the Delaware, Lackawanna and Western Railroad* (New York: McGraw-Hill Book Co., 1951).
3. "The Construction of the Hopatcong-Slateford Low-Grade Cut-Off of the Lackawanna Railroad," *Engineering Record* 59, No. 16 (17 Apr. 1909): 504-8, continued in *ibid.*, No. 17 (24 Apr. 1909): 541-4.
4. C. W. Simpson, "The Hopatcong-Slateford Cut-Off," *Railway Age Gazette* 53, No. 23 (6 Dec. 1912): 1091-5, continued in *ibid.*, 54, No. 1 (3 Jan. 1913): 9-14.
5. F. L. Wheaton, "The New Cut-Off Line of the Lackawanna Railroad," *Engineering News* 60, No. 7 (13 Aug. 1908): 176-7.
6. Wheaton, "The New Lackawanna Cut-Off," *Railroad Age Gazette* 45, No. 11 (14 Aug. 1908): 715-8.